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Estimating mortality in conflict settings: expert perspectives on methods, barriers, and ethical challenges

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Abstract

Background Estimating mortality in conflict settings is essential for effective humanitarian response yet remains fraught with methodological, political, and ethical challenges. Conventional techniques such as retrospective surveys, prospective surveillance, and multiple-source analysis, often collapse under insecurity, displacement, or censorship. Emerging approaches, including key-informant reporting, small-area estimation (SAE), satellite-based remote sensing, and social-media analytics, offer new possibilities but raise questions about bias, data ownership, and the ethics of digital surveillance. This study examined expert perspectives on how these methods are applied, adapted, and constrained in conflict-affected contexts.

Methods This qualitative study explored expert perspectives on mortality estimation in conflict-affected contexts. Twelve semi-structured interviews were conducted with humanitarian workers, public health specialists, and officials with direct experience in mortality estimation. The data were analysed thematically, following Braun and Clarke's six-phase framework, with codes reviewed collaboratively for consistency. Reporting adheres to the COREQ checklist.

Results Participants agreed that no single method is universally reliable. Ground-based approaches such as key-informant reporting were valued for their speed and community access but lost validity during prolonged displacement. SAE was regarded as statistically robust yet dependent on high-quality baseline data and specialised expertise. Non-ground-based approaches, including satellite imagery and social-media analytics, expanded visibility in inaccessible areas but introduced ethical and technical limitations related to surveillance, data ownership, and digital exclusion. Political interference, displacement-related logistical constraints, and community trust emerged as prominent cross-cutting considerations across participant accounts. These operational barriers reflect systemic weaknesses in public-health information and coordination structures during emergencies, underscoring the need for integrated surveillance frameworks across humanitarian and national health sectors. Differences also reflected conflict typology: protracted conflicts were dominated by political manipulation, whereas acute emergencies faced infrastructure collapse. Trust, coordination, and community engagement consistently enabled higher-quality data.

Conclusions Mortality estimation in armed conflict is not purely a technical task but also a political and ethical process. Multiple methods and context-sensitive strategies, combined with the transparent governance of digital tools, are needed to generate credible data that can inform humanitarian decision-making and advocacy.

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Introduction

Estimating mortality in conflict settings is notoriously difficult, yet it remains fundamental for informed humanitarian action [1]. Reliable mortality figures influence diplomatic negotiations, military strategy, legal accountability, and—most critically—the allocation of life-saving resources [2–5]. Authoritative humanitarian guidelines, including those of the Sphere Commission and the United Nations High Commissioner for Refugees (UNHCR), recommend declaring an emergency when the crude mortality rate (CMR) doubles from its baseline level. While such declarations cannot alter past deaths, they can mobilize funding, political will, and operational response to protect those still living [2].

For mortality data to guide action effectively, estimates must be produced and disseminated rapidly. Yet armed conflict severely constrains data collection through insecurity, population displacement, and damaged infrastructure [1]. Prolonged data-gathering efforts may delay response, exhaust limited operational capacity, and introduce avoidable biases [4]. Experience demonstrates that even imperfect but timely estimates can shift policy and save lives. During the 1992 Burma–Bangladesh refugee crisis, documentation of disproportionately high female mortality prompted the rapid establishment of free clinics for women, substantially reducing female deaths [6].

Three principal approaches dominate mortality estimation in emergencies. Retrospective mortality surveys (RMSs), frequently implemented using the SMART (Standardized Monitoring and Assessment of Relief and Transition) methodology, collect household-level data during or after conflict. These surveys are relatively inexpensive and capture deaths occurring outside health facilities, but they remain vulnerable to recall, survivor, response, and selection bias—particularly when access is restricted [7–10]. Prospective mortality surveillance (PMS), by contrast, relies on continuous reporting through health facilities, civil registration systems, or community health workers. While capable of providing real-time trends, it depends on functioning infrastructure and often collapses when systems are destroyed or populations are displaced [7]. Multiple-source analysis triangulates diverse datasets—including facility records, surveys, media reports, and satellite imagery—to improve accuracy. However, such analyses are typically conducted postconflict, limiting their operational value for immediate decision-making [7].

Within humanitarian practice, mortality data are translated into two key indicators. The crude mortality rate, expressed as deaths per 10,000 persons per day, signals emergency conditions when it exceeds twice the preconflict baseline [11, 12]. The under-five mortality rate (U5MR) serves as a sensitive proxy for indirect mortality, as young children are rarely direct combat targets [7, 13]. Comparing U5MR with CMR can help distinguish combat-related deaths from those resulting from disrupted health services, malnutrition, and infectious disease.

Accurate estimation is further complicated by structural, political, and contextual factors. Prior to conflict, weak governance and absent surveillance systems leave much of the global population without reliable vital registration [14]. During hostilities, authorities may restrict access, censor reporting, or manipulate figures [15]. Demographic composition shapes vulnerability: conflicts in low-income settings disproportionately affect children and young adults, whereas in higher-income contexts excess mortality may occur among the elderly [16]. Geographic variation also matters—deaths among rural or mobile populations frequently go unrecorded, while those in organized refugee camps are more consistently documented [7, 17]. Mortality patterns shift across conflict phases, rising during escalation, peaking with intense violence, and declining as assistance arrives, making static measurement approaches insufficient [16]. Modern conflicts, increasingly protracted and urbanized, further complicate estimation by disrupting interconnected health and service systems, while high-fatality rural conflicts continue to challenge assumptions about conflict geography [18–21].

The humanitarian community therefore faces an urgent research priority: developing rapid, low-bias mortality estimation methods suitable for insecure and access-constrained environments; accurately enumerating displaced populations outside formal camps; and addressing the political and economic barriers that impede transparent reporting. Without such advances, humanitarian response will continue to rely on delayed, incomplete, or contested mortality data.

This study aims to explore the contemporary methods and expert perspectives on how these approaches can be selected, combined, and governed to strengthen the credibility, usefulness, and ethical application of mortality estimates in conflict settings. By situating mortality estimation within the broader field of public-health surveillance and global-health governance, this study contributes to ongoing efforts to enhance data quality, transparency, and responsiveness during humanitarian emergencies.

Methods

Study design

This study employed a qualitative design using semi-structured expert interviews to explore perspectives on mortality estimation and public health responses in conflict settings. A qualitative approach was selected because it enables in-depth examination of how methodological choices are made under conditions of insecurity, access constraints, and contested information. The study focused on identifying perceived barriers, enablers, and context-specific considerations that shape the feasibility and credibility of mortality estimation approaches.

Participants and sampling

Participants were selected on the basis of specific inclusion criteria: public health experts, humanitarian workers, and officials with direct experience in mortality estimation, epidemiology, or biostatistics, particularly in conflict-affected settings. All participants were over 18 years of age and fluent in English. Given feasibility and safeguarding constraints, recruitment prioritized experts who could be interviewed remotely. The study aimed to synthesize expert perspectives on methodological and governance considerations in mortality estimation; perspectives of frontline local data collectors and non-English speakers are likely underrepresented and are highlighted as a priority for future research.

A snowball sampling strategy was employed, beginning with a curated list of professionals within the global health and humanitarian cluster. Each participant was asked to recommend additional contacts. Recruitment continued until thematic saturation was reached, defined as the point at which additional interviews did not generate new codes or meaningfully extend the existing thematic structure. Analysis was conducted concurrently with data collection; after each interview, the coding framework was updated and reviewed. Saturation was judged to have been reached by the twelfth interview, as the final interviews primarily reinforced existing themes rather than contributing new codes.

Data collection

Semi-structured interviews were conducted by two team members (T.R. and R.A.) over a one-month period via Zoom. Each session lasted approximately 45–60 min. A written informed consent to participate was obtained from the participant before each interview. The interview questions focused on participants' experiences with mortality estimation methods, coordination challenges, and barriers/enablers in data collection. The full interview guide is included as a supplementary material.

Data analysis

Thematic analysis was conducted manually via an Excel-based matrix. An inductive coding approach was employed: transcripts were reviewed iteratively to generate initial codes, which were then grouped into higher-order categories through team discussion. Although several themes align with well-recognized challenges in conflict epidemiology, the inductive process was used to capture how participants described mechanisms, trade-offs, and context conditions shaping feasibility and credibility. The analysis followed Braun and Clarke's six-phase framework, which includes becoming familiar with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. After initial coding, candidate themes were generated by grouping related codes and examining patterns across transcripts (phase 3). Themes were then reviewed against the coded extracts and the full dataset to assess coherence and distinctiveness, with iterative refinement through analytic discussion (phase 4). Final themes were defined and named by specifying their scope, boundaries, and relationships to subthemes, and were then used to structure the Results narrative (phase 5).

Reflexivity and rigour

Two researchers (T.R. and R.A.) independently coded an initial subset of transcripts and then met to compare interpretations, resolve discrepancies through discussion, and refine a shared codebook. Remaining transcripts were coded iteratively with regular analytic meetings to review code application and refine theme definitions. Formal intercoder reliability statistics were not computed, as reflexive thematic analysis emphasizes interpretive depth, reflexivity, and transparency over numerical agreement; however, analytic rigor was strengthened through initial double-coding, consensus discussions, and documented coding and theme-development decisions. Both interviewers had professional experience in public health and humanitarian response but no operational role within participants' organisations. This outsider status helped minimize potential bias during data collection and analysis while allowing informed interpretation of participant perspectives. Reflexive memoing and team discussions were used to examine how disciplinary backgrounds and prior assumptions could shape interpretation, with attention to alternative explanations and disconfirming excerpts during theme refinement.This study follows the COREQ (Consolidated Criteria for Reporting Qualitative Research) checklist, which is provided in the supplementary materials.

Ethics approval and consent

Ethics approval was granted by Qatar University (QU-IRB 355/2024-EA) prior to data collection. A written informed consent to participate was obtained from all the participants before each interview. To reduce identifiability in a small expert community and in relation to politically sensitive topics, transcripts were de-identified at the point of transcription, with names, organisations, and specific locations removed or generalized. Reported quotations were reviewed to omit potentially identifying operational details, and participants are referenced only using anonymized labels and broad role descriptors. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

The participants' description (such as areas of work and expertise) can be found in Table 1. The participants had extensive experience across conflict-affected regions in Africa, the Middle East, Asia, and Eastern Europe and had diverse expertise in medical coordination, surgery, health systems, and disaster management. Collectively, they provided a comprehensive understanding of the multifaceted challenges in mortality estimation and humanitarian response across diverse settings.

Thematic analysis identified four overarching themes (with related subthemes): (1) enablers and barriers to mortality estimation (2), contemporary methods of mortality estimation (3), cross-cutting and contextual factors, and (4) ethical and validation considerations. Fig. 1 shows the mind map of the themes and subthemes of the analysis, and Table 2 shows the themes, subthemes, and illustrative participant quotes.

Enablers and barriers

The participants unanimously agreed that mortality estimation in conflict zones is both essential and highly complex. While shared concerns were common, divergences emerged on the basis of the nature and typology of the conflict. For example, those working in protracted, politically sensitive conflicts – such as Syria, Yemen, and Gaza – described political interference, censorship, and disinformation as major obstacles. Several participants explicitly cited the political manipulation of mortality figures. Participant 5 stated, "*The main challenge in most long-term emergencies is the absence of any formal birth or death registration; the state often doesn't want you to know how many people have died.*"

Many participants emphasized logistical barriers such as the destruction of infrastructure, displacement, and lack of access to remote populations. Participant 3 described the difficulties of verification: *"How do you count bodies buried under rubble or when people are burying their dead in the night out of fear?"*

Cultural and social barriers were also highlighted by three participants, particularly where cremation practices or communities mistrust limited data collection. As one respondent explained, *"If people don't trust who is asking, they will not share death records, even if they exist."*

In contrast, enablers were reported by many participants. These included functioning civil registries, ministries of health, and digital reporting systems in more stable urban contexts such as Iraq and Ukraine. Trust – whether institutional or community-based – was cited as a universal enabler. Participant 7 noted, *"You can only obtain good mortality data if the community trusts you, otherwise they'll tell you what they think you want to hear."* Effective RCCE (Risk Communication and Community Engagement) frameworks and coordination among NGOs, governments, and UN agencies were also

Table 1 Participants description

Participant	Role/Title	Regions/Countries of Experience	Focus Area(s)
1	WASH Advisor	Ethiopia, Mozambique	Water, sanitation, hygiene (WASH)
2	Medical Coordinator	Ukraine, Gaza	Medical coordination
3	Plastic Surgeon, Armed Forces Advisor	Afghanistan, Ukraine, Gaza	Surgery, conflict medicine
4	WHO Staff	Sub-Saharan Africa, Southeast Asia	Humanitarian health systems
5	Humanitarian Response Expert	Ukraine	Humanitarian response
6	Trainer	Syria, Afghanistan, Somalia, Ukraine, DRC, North Korea, Myanmar	Humanitarian training, emergency response
7	Emergency Medicine & ICU Specialist	Syria, South Sudan, Yemen	Hospitals, ICU, refugee camps
8	Global Health Advisor	Gaza, Yemen, Lebanon	Health systems strengthening
9	Maternity Health Specialist	West Bank, Gaza, Mozambique, Southeast Africa	Maternity health in conflict
10	Head of an Emergency Medical Team	Balkans, Iraq, Middle East, South Sudan, Syria, Lebanon, Yemen, Africa, Ukraine, Nepal	Emergency medical teams, field operations
11	Health Director of NGO	Ukraine, Sudan, Yemen, Gaza	Disaster management, emergency contexts
12	Executive Director of Emergency Hospitals	Ukraine	Trauma, burns, psychosocial support

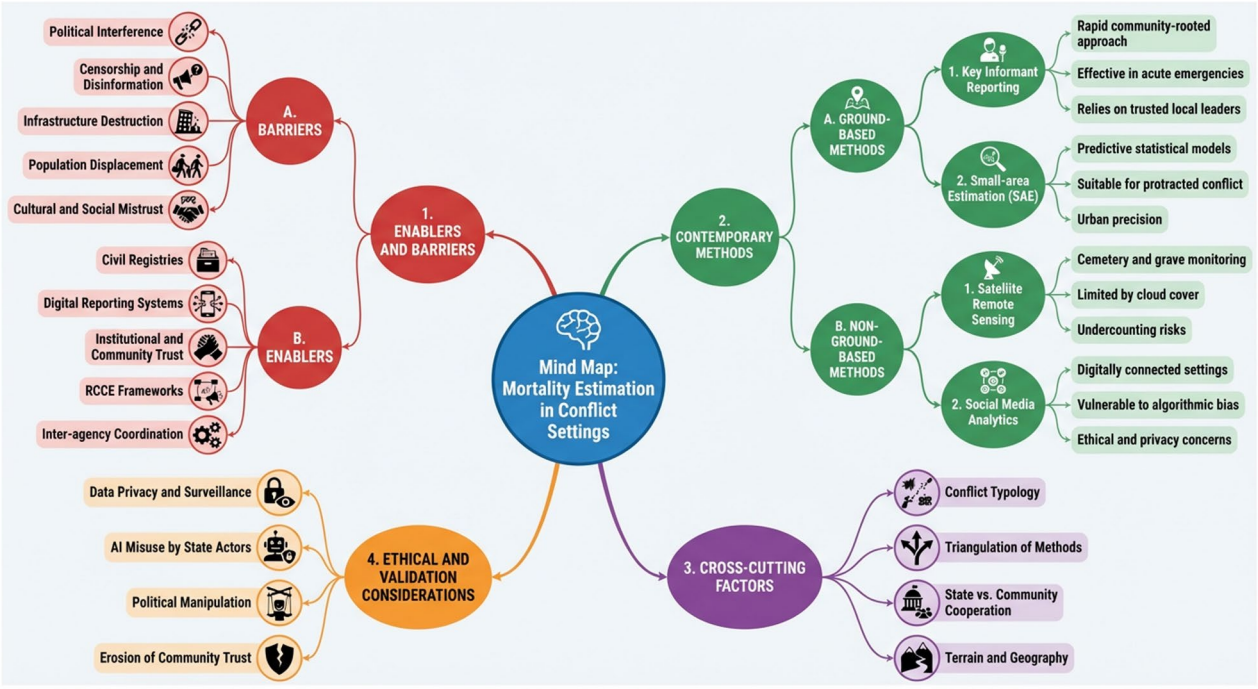

Fig. 1 Mind map of the themes and subthemes of the analysis

Table 2 Themes, subthemes, and illustrative participant quotes

Theme (domain)	Subtheme	Illustrative quote
Enablers and barriers to mortality estimation	Weak/absent registration systems + state obstruction	*"The main challenge in most long-term emergencies is the absence of any formal birth or death registration, the state often doesn't want you to know how many people have died."* (Participant 5)
	Verification challenges under insecurity	*"How do you count bodies buried under rubble or when people are burying their dead in the night out of fear?"* (Participant 3)
	Trust as a barrier to disclosure	*"If people don't trust who is asking, they will not share death records, even if they exist."* (Participant 2)
	Trust as an enabler (community buy-in)	*"You can only obtain good mortality data if the community trusts you, otherwise they'll tell you what they think you want to hear."* (Participant 7)
Contemporary methods of mortality estimation	Method selection must be context-specific	*"You have to tailor the method to the terrain - political, geographic, and social. There's no one-size-fits-all."* (Participant 2)
	Limits of key-informant reporting under displacement	*"Once people start fleeing, your informants don't know anymore, they can only speak for who's still there."* (Participant 4)
	Technical + political expertise needed for SAE	*"You need people who understand both the numbers and the politics behind the numbers."* (Participant 6)
Cross-cutting and contextual factors	Triangulation to reduce bias/contested narratives	*"If you rely on one method, you get one version of the truth – often the one someone wants you to see."* (Participant 10)
Ethical and validation considerations	Risk of surveillance/misuse	*"It's not hard to imagine these tools being used to track dissidents instead of count the dead."* (Participant 8)
	Control of infrastructure shaping "the story"	*"when governments control the imagery or the servers, they control the story, and humanitarian actors can become complicit if they don't question the source."* (Participant 5)
	Digital blackout / bias in social media data	*"Governments shut off the internet right when people start dying — then you're blind."* (Participant 6)
	Limits of remote sensing (undercounting)	*"A satellite can't see under a collapsed building,"* (Participant 9)

seen as critical enablers. However, participants acknowledged variation: in Ukraine, overlapping data silos across agencies caused duplication, whereas in Iraq, central registries improved standardization.

Overall, the results show that barriers and enablers differ across conflict typologies. Protracted, politically sensitive conflicts were shaped primarily by manipulation and censorship, whereas acute-onset crises were constrained by infrastructure collapse and a lack of baseline data. In rural areas, low-governance contexts, community-based methods and trust networks were the main pathways for obtaining mortality data.

Contemporary methods of mortality estimation

The participants consistently noted that method selection must be conflict specific. Participant 2 stated, *"You have to tailor the method to the terrain - political, geographic, and social. There's no one-size-fits-all."* Methods were categorized as ground-based or non-ground-based.

Ground-based methods

Ground-based methods require data collection from within the affected areas and are highly context sensitive. The participants emphasized that the effectiveness of these methods depends heavily on security, community trust, and local infrastructure. Two primary approaches were discussed: key-informant reporting and small-area estimation (SAE).

Key-informant reporting Participants consistently identified key-informant methods as a rapid, community-rooted approach to mortality estimation. This method was seen as particularly effective in acute emergencies or remote rural settings where formal health systems were absent. Informants – often community elders, religious leaders, or local health workers – were trusted sources of near real-time information. Several participants emphasized its utility in high-displacement settings, where formal registries collapse and informal networks become primary sources of information. However, the method's reliability declines over time, especially in protracted crises or where key informants themselves are displaced.

Participant 4 explained that the method works best over short recall periods and in areas without significant population movement: *"Once people start fleeing, your informants don't know anymore, they can only speak for who's still there."* The method's scalability was also questioned, with some experts warning against extrapolating localized data without validation.

Small-area estimation: SAE is a statistically robust method suitable for protracted conflicts with partial data availability. It allows mortality estimation via predictive models based on localized samples, thus reducing the need for full-area coverage. Several participants noted that SAE is less resource intensive than traditional surveillance but still demands technical expertise, reliable baseline data, and contextual understanding. Participant 6 noted, *"You need people who understand both the numbers and the politics behind the numbers."*

The method was seen as particularly advantageous in urban settings, where administrative boundaries and existing datasets can enhance precision. However, limitations included population mobility, fluctuating conflict intensity, and the risk of political manipulation of baseline figures. The participants cautioned that, while the SAE is powerful, misuse of poor-quality inputs could amplify bias rather than mitigate it.

Across both methods, there was strong consensus that triangulation is essential. Key informant reports offer speed and immediacy, whereas SAEs offer structure and statistical weight. Used together, and critically evaluated against context, they can produce mortality estimates that are both timely and credible.

Non-ground-based methods

Satellite imagery and social media analytics were discussed as complementary tools that can enhance or triangulate ground-based methods, especially in inaccessible or politically restricted zones.

Satellite-Based Remote Sensing: This method is perceived as particularly useful in urban, high-density conflict zones where ground access is limited. The participants noted that it is frequently used to monitor cemetery expansion, infrastructure damage, or signs of mass graves. However, its utility depends on preconflict baseline imagery, image resolution, and the ability to differentiate conflict-related deaths from natural mortality.

Limitations include cloud cover, urban density, and burial practices such as cremation or informal burials in unobservable areas. Participant 9 noted, *"A satellite can't see under a collapsed building,"* pointing to the risk of undercounting.

Social media analytics Although often viewed as innovative, this method raises substantial ethical and methodological concerns. The participants described social media analytics as promising in digitally connected urban settings but warned of inconsistent access, censorship, and algorithmic bias. For example, governments may intentionally cut internet access during conflict spikes, limiting visibility. Others cautioned against misclassification by automated systems and the risk of overlooking marginalized populations who lack digital access.

The participants also warned that social media-based estimates are vulnerable to both state propaganda and public misinformation and often lack ground validation. As Participant 6 summarized, *"Governments shut off the internet right when people start dying — then you're blind."*

Cross-cutting themes

Participants frequently emphasized the importance of combining methods based on typology: in acute rural settings, key informants and RCCE were critical; in protracted urban conflicts, triangulation using SAE and satellite data was ideal. Divergences emerged most sharply in contexts of state interference versus community cooperation.

Participant 10 summarized this sentiment: *"If you rely on one method, you get one version of the truth – often the one someone wants you to see."*

Table 3 Summary of the four dominant mortality estimation methods as identified through participant interviews

Method	Minimum data requirements	Main advantages	Key limitations	Best-fit operational context
Key-informant reporting	List of trusted community informants; basic death details (name/age/date)	Very low cost; rapid set-up; feasible with minimal technical skills	Under-counts once populations disperse; recall and survivor bias; accuracy falls in prolonged crises	Early phase of localised violence with limited displacement
Small-area estimation	Ground "sentinel" clusters plus contextual covariates (population density, remoteness, livelihood)	Generates district-level rates; statistically rigorous; can run with sparse field data	Requires trained statisticians & modelling software; relies on predictor datasets that may be outdated	Medium-term conflicts where population distribution is relatively stable and covariate data exist
Satellite-based remote sensing	Access to high-resolution imagery (burial sites, building damage) and geospatial expertise	No physical presence needed-safe in denied areas; objective visual record; scalable	Commercial/state control of imagery; cloud cover & urban canopies hinder detection; ethics of external surveillance	Protracted or siege conflicts where ground access is impossible; areas with open terrain cemeteries
Social-media analytics	Public posts (tweets, Facebook/WhatsApp, obituaries) and machine-learning pipeline	Near real-time signal; captures urban, tech-connected populations; complements official data	Collapses during internet shutdowns; language/irony confound AI; sparse in rural/low-connectivity areas	Urban wars with high smartphone penetration and intact networks

Overall, the findings show that no method is universally superior. Political dynamics, displacement, terrain, and local trust networks each shape the optimal strategy for mortality estimation during a crisis.

Ethical and validation considerations

While technological innovation has expanded the possibilities for mortality estimation in conflict zones, participants expressed strong concerns about the ethical implications of AI-supported and remote sensing approaches. Issues around surveillance, data privacy, and control of technologies by state or military actors were particularly salient. For example, participants highlighted how AI models trained on social media or remote-sensed data could be repurposed for state surveillance or disinformation, especially in authoritarian contexts. Participant 8 noted, *"It's not hard to imagine these tools being used to track dissidents instead of count the dead."* Similarly, Participant 5 cautioned that *"when governments control the imagery or the servers, they control the story, and humanitarian actors can become complicit if they don't question the source."* These reflections underscore the tension between technological efficiency and ethical accountability, revealing how the tools intended to improve humanitarian response may risk reinforcing political manipulation or eroding community trust. Table 3 summarizes the four dominant mortality estimation methods as identified through participant interviews.

Discussion

This study was conducted to synthesize expert perspectives on mortality estimation in conflict settings, particularly in contexts where insecurity, access constraints, displacement, and contested narratives complicate the generation and interpretation of mortality figures. The analysis yielded four key findings. First, experts emphasized that mortality estimation is inherently context-dependent, with method selection shaped by conflict typology, displacement dynamics, and the integrity of administrative and health infrastructure. Second, political interference and access constraints were dominant barriers, while trust and coordination consistently enabled higher-quality estimates. Third, non-ground-based approaches (including satellite imagery and digital traces) can extend visibility in inaccessible areas but introduce technical limitations and ethical risks. Fourth, participants repeatedly emphasized triangulation, not as an abstract ideal, but as a practical necessity to reduce bias and strengthen credibility in contested information environments.

Appraisal of methods

The appraisal of the four dominant approaches – key-informant reporting, small-area estimation, satellite-based remote sensing, and social media analytics – showed distinct advantages and constraints. Key informant surveys have been shown in other contexts to provide rapid, community-level data during acute crises [22], but their validity decreases with displacement and protracted violence, which is consistent with our findings. The SAE has been promoted in the public health literature for generating statistically robust estimates from limited data [23]. However, as our participants noted, its technical complexity and reliance on high-quality baseline data limit its field application. Remote sensing has been used effectively in Syria and Yemen, but as in prior studies, we found that imagery access and interpretation are constrained by political and commercial interests. Social-media analytics remain largely experimental, with a growing body of literature pointing to promise in crisis informatics but also highlighting the lack of systematic validation [10, 24].

Implications for humanitarian actors

The study highlights operational implications for humanitarian actors. Because no single tool is universally reliable, practitioners must triangulate across at least two methods and adapt strategies to the conflict phase, displacement dynamics, and infrastructure integrity. This aligns with prior research emphasizing methodological pluralism in humanitarian epidemiology [25]. Triangulated estimates not only increase accuracy but also strengthen advocacy for resources and improve the targeting of interventions. Building partnerships with local actors is essential since trust and contextual knowledge are critical enablers, a point also echoed in studies of community-based surveillance [12].

Building on these implications, participants' accounts also point to several practical considerations for implementation. Method selection should be explicitly grounded in the operating context, including access constraints, population movement, and the availability of reliable denominators [10]. Where feasible, triangulation should draw on at least two complementary sources, with transparent documentation of what each approach is likely to miss [25]. Community engagement should be treated as a core methodological requirement rather than an add-on, including working through trusted intermediaries and communicating clearly why mortality data are collected and how they will be used [12]. Meaningful engagement can be operationalized by involving local partners in defining locally appropriate indicators and safe reporting channels, and by establishing feedback loops in which aggregated findings are shared back to communities and local responders in ways that do not increase risk [26]. To reduce tokenism, roles, decision points, and risk-mitigation measures should be agreed in advance and documented [27].

When non-ground-based approaches are used, additional safeguards are required to minimize harm, including data minimization (collecting only what is essential), restricted access and secure storage, avoiding unnecessary collection/reporting of sensitive attributes, and explicit assessment of downstream misuse risks (e.g., surveillance or targeting) in contested environments [28]. In addition, a minimum reporting standard would improve comparability and credibility; at a minimum, studies should state the recall period, denominator assumptions, displacement levels, access constraints, verification approach, and data-protection measures [7].

Expert perspectives should be translated into operational guidance that differentiates by conflict typology. In acute, high-intensity settings with limited access, rapid and low-burden approaches—such as key-informant networks combined with remote sensing—may be prioritized to provide timely situational awareness. In protracted or partially stable contexts, hybrid models integrating small-area estimation with periodic ground validation may be more feasible. Urban conflicts may allow greater use of digital trace and facility-based data, whereas rural or highly mobile populations may require stronger reliance on community-based reporting. Across contexts, method selection should be guided by access, population mobility, denominator reliability, and political constraints, ensuring that mortality estimation strategies are aligned with operational realities while maintaining ethical safeguards.

In addition to methodological choices, emerging technical initiatives aimed at improving interoperability and patient control over health data may strengthen the information base needed for mortality estimation where functioning health information systems exist. For example, the Global Patient co-Owned Cloud (GPOC) has been proposed as a patient-centric, interoperable personal health record infrastructure, with published work describing its rationale, technical sandbox, and associated ethical and legal considerations. While such platforms may be difficult to implement in acute or connectivity-constrained conflict settings, they illustrate a direction of travel for strengthening longitudinal health records, continuity of care, and data availability, all of which are factors that could improve the precision and verification of mortality-related estimates in more stable or protracted contexts [29–31].

Ethical and political considerations

Our findings extend current debates on the ethics of digital humanitarianism. Several participants highlighted that mortality-related data and digital traces can be repurposed in contested environments, creating risks of surveillance, intimidation, or targeting of specific communities and human rights actors. These risks may be heightened where health information systems are weak, governance is contested, or access to datasets is controlled by state or commercial actors. Concerns about surveillance, data privacy, and the politicization of mortality figures parallel warnings in the broader literature on humanitarian technology [28]. The concentration of control over satellite imagery and AI platforms by state and commercial actors raises equity and accountability questions, similar to critiques raised in recent reviews of remote sensing ethics [32]. For humanitarian organisations, the challenge is to use these tools while safeguarding neutrality and protecting affected populations from harm.

Evidence gaps and research priorities

This study underscores several areas where further research is urgently needed. Validation studies comparing remote, statistical, and informant-based estimates against gold-standard surveys are rare but essential for

building confidence in new approaches. The integration of methods through Bayesian or machine learning frameworks represents a promising research frontier [33]. Finally, ethical governance models are needed to address data ownership, consent, and accountability in AI-driven mortality estimation, which is consistent with calls in the recent public health ethics literature [34].

Strengths and limitations

This study has several strengths. It draws on diverse perspectives from experts with field experience across multiple conflict-affected regions, providing rich, practice-oriented insights that complement the existing methodological literature. The use of semi-structured interviews allowed for depth and flexibility, whereas thematic analysis guided by Braun and Clarke's framework provided a systematic approach to identifying key themes. In addition, the study highlights ethical and political dimensions that are often overlooked in technical debates about mortality estimation.

There are, however, limitations; the sample size was modest and limited to English-speaking professionals, which may underrepresent perspectives from non-Anglophone or local actors most directly involved in field data collection. Importantly, the exclusion of non-English speakers and frontline local data collectors (e.g., community health workers and enumerators) limits insight into ground-level implementation realities and may bias findings toward internationally networked viewpoints. Findings should therefore be interpreted as expert-informed themes about methodological and governance challenges, and not as a substitute for locally grounded perspectives. While efforts have been made to capture the breadth of experiences, snowball sampling may have introduced selection bias toward more internationally connected experts. In addition, as participants were experts actively engaged in humanitarian and public health practice, their views may reflect role- and experience-related perspectives. This risk was mitigated through inclusion of diverse professional roles and experiences and through reflexive, team-based analysis. The analysis did not include formal intercoder reliability testing, which may limit reproducibility, although coding was conducted collaboratively to enhance rigour. Finally, while this qualitative design provides valuable exploratory insights, it cannot quantify the effectiveness or accuracy of specific methods, underscoring the need for empirical validation in future research.

Conclusion

Accurate mortality estimation is a cornerstone of evidence-based public-health decision-making in emergencies. This study shows that while multiple methods exist, their credibility depends on context-specific adaptation, trust, and transparent governance. Combining community-based and statistical approaches can strengthen the credibility and operational usefulness of estimates, and may improve accuracy when paired with clear verification and triangulation procedures. The findings highlight that methodological innovation must be matched by ethical safeguards and strong coordination between humanitarian and national health systems. Strengthening mortality surveillance capacities in conflict-affected regions is essential for timely response, equitable resource allocation, and global accountability. This requires investments in trained local and partner teams, secure data-management workflows with restricted access, routine triangulation and verification protocols, and governance arrangements that include data-protection measures and misuse-risk assessment.

Abbreviations

RMS	Retrospective mortality surveys
PMS	Prospective mortality surveillance
CMR	Crude mortality rate
U5MR	Under 5 mortality rate
SAE	Small-area estimation
NGO	Non-governmental organisation
RCCE	Risk communication and community engagement
COREQ	Consolidated Criteria for Reporting Qualitative Research

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-026-26831-5.

Supplementary Material 1.

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Authors' contributions

TR - Conceptualisation of the project. Conducted interviews. Writing, review and editing of manuscript. IH - Design of the work. Review and editing of manuscript. RA - Design of the work. Conducted interviews. Analysed and interpreted results. Review and editing of the manuscript. RV - Conceptualisation of the project, design of the work. DM - Conceptualisation of the project, was responsible for selecting and contacting participants, review and editing of manuscript. NG – Review and editing of manuscript. YA – Review and editing of manuscript.

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Data availability

Recordings of interviews conducted for the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethics approval was granted by Qatar University-QU-IRB 355/2024-EA. A written informed consent was obtained from all participants before each interview. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests
The authors declare no competing interests.

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